2	Earth work for Excavation & Subgrade (Bill No. 2)
3	Concrete of all grade and Steel Work for Drain, Manhole, Basement for Street Light Pole (Bill No. 3)
4	Sub Base work for GSB & WMM (Bill No. 4)
5	Masonry and Finishing works for Footpath, Kerb, utility Duct etc (Bill No.5)
6	Base and Surface work for DBM & BC (Bill No. 6)
7	Pavement marking and Road Appurtenances (Bill No. 7)
8	Construction of Recharge pits for Rain water Harvesting (Bill No. 8)
9	Tree Plantation and Transplantation (Bill No. 9)

Traffic Survey and Analysis

General

e present chapter on traffic survey and analysis presents the existing traffic racteristics, methodology used to derive traffic growth rates, details on adopted traffic wth rates, forecasted traffic on the project road. Based on these the results of analysis l recommendations for improvements are discussed in the following sections.

e methodology adopted for traffic surveys is as per IRC standards. A thorough owledge of traffic travel characteristics is required for future traffic estimation. Therefore, ffic surveys have been conducted to assess the basic traffic characteristics of the area rounding the project

e study aims at obtaining the existing traffic and travel characteristics on the project road d forecasting the average annual daily traffic for project horizon year considering various nsistent streams and for various scenarios. Classified Volume Counts

e traffic count surveys were conducted for Fifteen hours from morning 6am to evening m to obtain classified count at the identified locations. The data was collected on working y by deploying enumerators to record data for each hour within fifteen minutes intervals obtain data on the magnitude of traffic flow, hourly variation and the traffic composition.

ne survey was carried out by manual vehicle counting and classifying the vehicles passing e survey station in both directions, in 15 minutes intervals. The counts were made parately for motorized and non-motorized traffic as per the vehicle classification system

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Traffic Volume Characteristics

affic volume count data collected at different locations has been analyzed to arrive hourly riation and composition. Total vehicles are worked out. Since the data collected from the e for the various vehicle types having different sizes and characteristics are to be nverted into a standard equivalent unit called Passenger Car Unit (PCU) has been adopted he PCU conversion factors adopted for the present study are given in Table 4-3 and are ken from "IRC 106-1990: Guidelines for capacity of Urban Roads in Plain Areas"

Table 4-3 Adopted PCU Values

Vehicle Type	PCU Factor
Two Wheelers	0.75
Auto Rickshaw	2.0
Car	1.0
Mini Bus	1.0
Standard Bus	2.2
Light Truck (LCV)	1.4
Medium Truck (HCV)	2.2
MAV	4.0
Agricultural Tractor	4.0
Animal Drawn	1.5
Hand Drawn	2.0
Cycle	0.4

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e Composition of traffic

road observes about 4714 Vehicles (3849 PCU) covering Morning to Evening g Peak hours. Hourly counts of different types of vehicles are shown in the

ow and composition of fast moving motorized vehicles is about 95.42 percent. of vehicles and percentage of compositions in hourly are shown in Figure 4-1 -2 below. Graphical representation of Hourly variation of traffic is shown in

Table 4-4 Classified Volume Count of different types of vehicles

Mini Buses	Cars/ Jeeps	Pickup Vans/ Maxicabs	Two Wheelers	Passenger Auto	2-Axle Trucks	3-Axle Trucks	MAVs	LCVs	GOODs AUTO	Tractor Trailer	Bi-Cycles/Cycle Rickshaw	Hand cart/Animal Drawn	Others	Total Vehicles	Total Vehicles in PCU
0	10	1	80	6	1	0	0	0	8	0	6	0	0	112	99
1	73	2	219	3	1	0	0	0	0	0	8	0	0	307	252
1	60	4	452	3	0	0	0	0	0	0	3	0	0	524	413
0	26	2	553	1	0	0	0	0	4	1	1	0	0	588	455
0	64	0	501	1	0	0	0	0	0	0	1	0	0	568	444
0	54	0	343	0	0	0	0	3	0	0	0	0	0	400	315
0	39	0	198	5	0	0	0	2	1	0	6	0	0	251	204
0	34	0	106	3	0	0	0	1	1	0	3	0	0	148	124
0	37	0	145	4	0	0	0	0	1	0	4	0	0	192	159
1	42	0	223	3	0	0	0	0	16	0	3	0	0	288	240
0	58	0	163	2	0	0	0	1	40	0	2	0	0	266	242
0	51	0	188	1	0	0	0	0	35	0	1	0	0	276	243
0	25	0	208	2	0	0	0	0	24	0	2	0	0	261	219
0	19	2	290	5	0	0	0	0	10	1	5	0	0	332	269
0	13	2	154	12	0	0	0	0	8	0	12	0	0	201	171
3	605	13	3823	51	2	0	0	7	148	2	57	0	0	4714	3849

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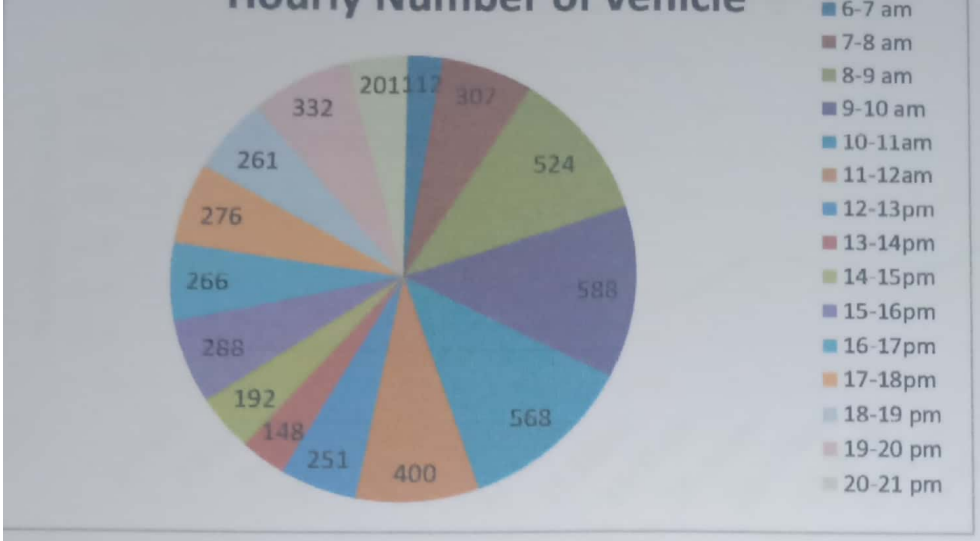
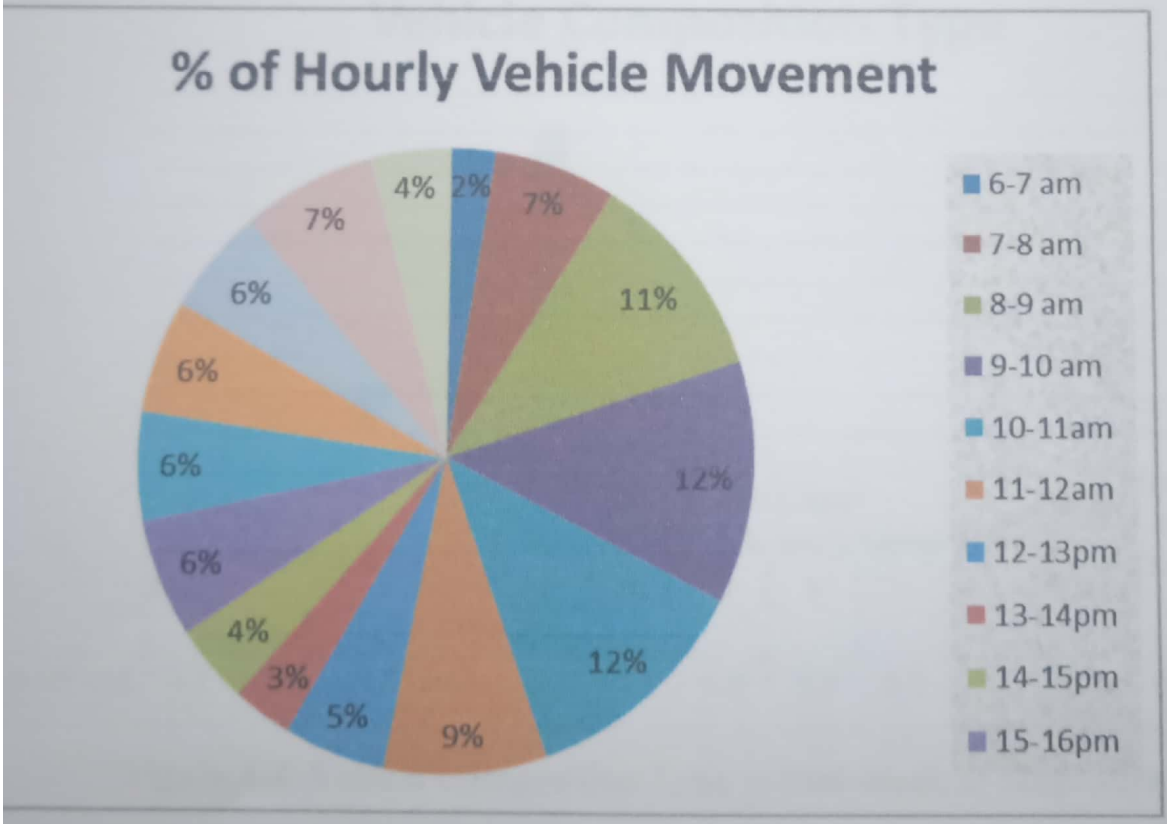


Figure 4-1 Hourly Vehicle Traffic (Number) in Singapura Road



ıre 4-2 Hourly Variation Traffic in Singapura Road

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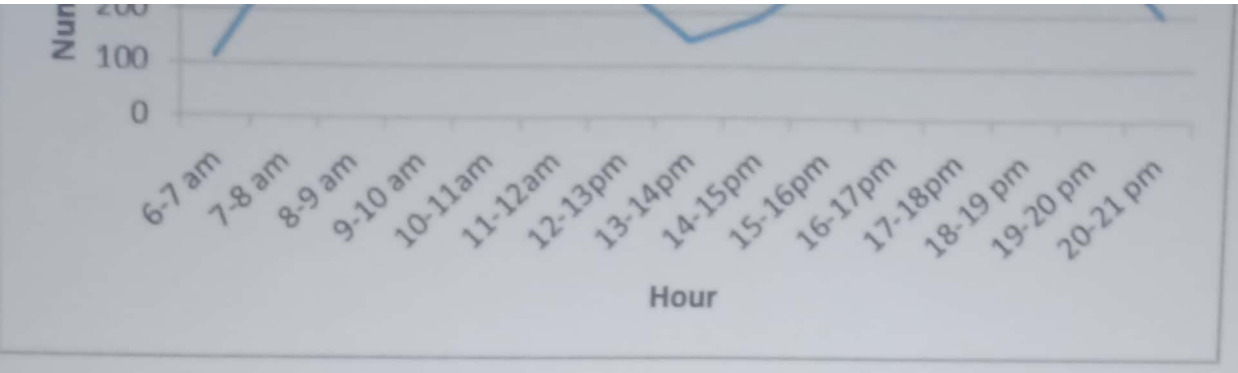

Figure 4-3 Hourly variation of Traffic Flow

The percentage share of different category of vehicles in the total traffic stream in terms of number of vehicles at the survey location has been analyzed. The traffic composition observed in this survey locations are plotted graphically is shown in Figure 4-4 below.

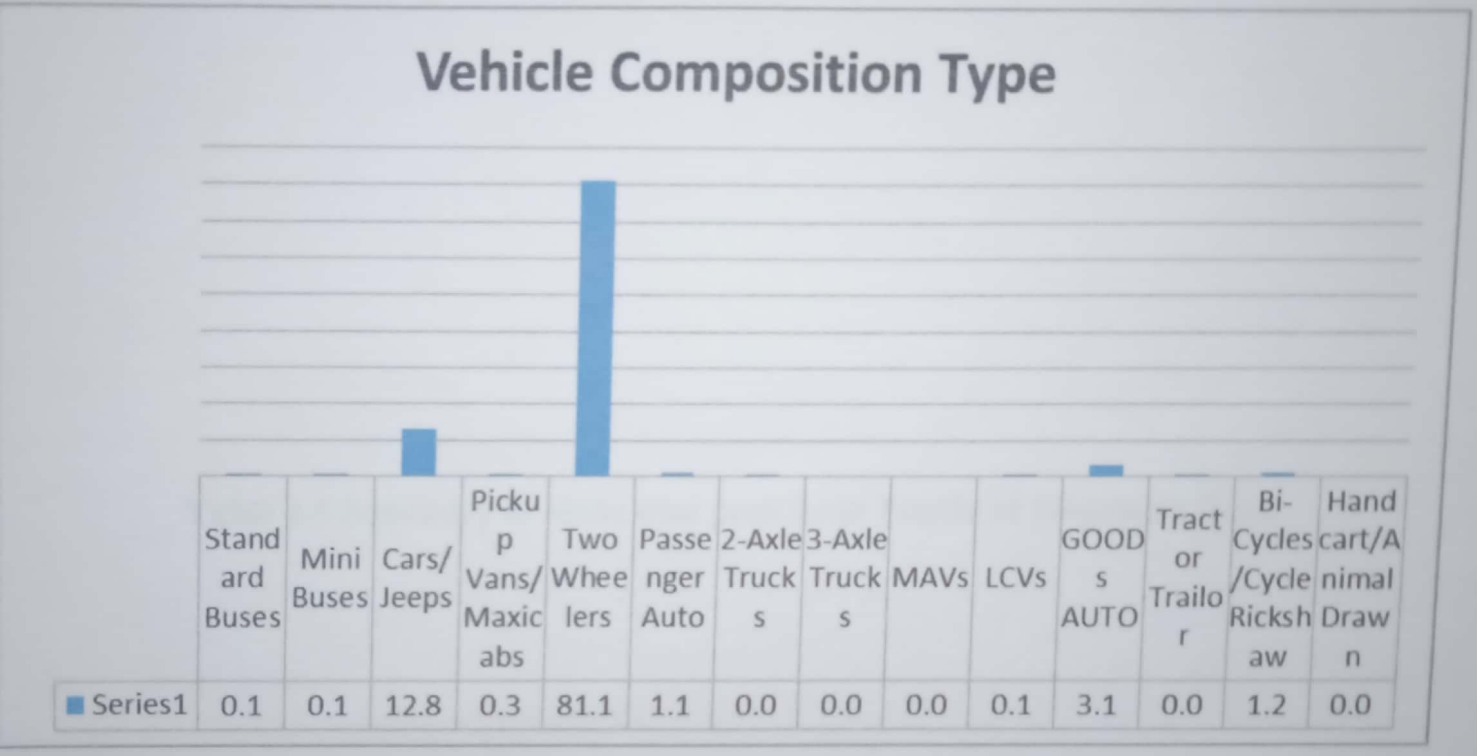

Figure 4-4 Vehicle Composition Type at Mid-block of Singapura Road

From the above Graphs followings are assessed

Goods vehicles account for 3.3 % and passenger vehicles account for 95.5 % of the total traffic. Non-motorized traffic constitutes about 1.2 % of total vehicles.

Among the passenger vehicles, two wheelers constitute about 81.1 % whereas cars, buses and auto rickshaws, constitutes about 12.8 %, 0.2 % and 1.1 % respectively.

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Wheelers	2068	87.07	840	84.93
Auto Rickshaw	8	0.34	20	2.02
Car/ Jeep	277	11.66	108	10.92
Mini Bus	2	0.08	0	0.00
Stand. Bus	2	0.08	0	0.00
LCV	3	0.13	0	0.00
2-Axle	1	0.04	0	0.00
3-Axle	0	0.00	0	0.00
Multi Axle	0	0.00	0	0.00
Tractor	1	0.04	1	0.10
Animal	0	0.00	0	0.00
Cycle	13	0.55	20	2.02
Total	**2375**	**100.0**	**989.0**	**100.0**

Total Traffic Volume in Singapura Road (CH: 0to CH:655)

Road between Abbigere Main Road to Singapura Access street is two way. Traffic flow in PCU in Singapura Min road for both the directions is 4714. Total two way traffic volume in this road is 3849 PCU.

From the above, Daily Traffic indicating major share of traffic is Two wheelers & Cars

Traffic Projection

Traffic Forecast

The vehicle population in Bengaluru started growing rapidly since later part of 1980s. The liberalization policy of the country made availability of not only vehicles but also loans for buying vehicles. With the rapid growth of IT sector in Bengaluru, the affordability of larger segment of employees increased for ownership of vehicles, more specially two wheelers.

Traffic growth rates have been estimated for the traffic flowing on the primary network within the city of Bangalore. The overall traffic growth rates have been estimated considering the growth rate used for passenger trip forecast as per the recommendations of Comprehensive Traffic and Transportation Plan (CTTP) for Bangalore, 2025 and the DPR

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Bangalore, the vehicle registration data of the city has been collected. The annual growth rates of motor vehicles and Compound Average growth rate (%) of different vehicle types is shown in Table 4-6

Table 4-6 Growth of Motor Vehicles in Bengaluru (in Lakh)

Year	TW	Cars	Autos	Buses	Trucks	Maxi Cab	Tractors / Trailers	Others	Total Vehicles
1980	1.12	0.36	0.1	0.05	0.08	0	0.04	0.01	1.75
1985	2.16	0.6	0.1	0.05	0.12	0	0.01	0.02	3.07
1990	4.59	0.91	0.17	0.05	0.19	0	0.04	0.04	5.98
1995	6.49	1.26	0.37	0.11	0.29	0.02	0.06	0.1	8.71
2000	10.67	2.14	0.61	0.21	0.42	0.04	0.12	0.17	14.38
2001	11.62	2.36	0.64	0.23	0.48	0.05	0.13	0.16	15.66
2002	12.92	2.61	0.68	0.25	0.53	0.05	0.15	0.2	17.39
2003	14.19	2.87	0.72	0.28	0.59	0.07	0.16	0.24	19.12
2004	15.86	3.36	0.74	0.34	0.68	0.1	0.2	0.28	21.57
2005	18.11	3.87	0.8	0.37	0.85	0.13	0.23	0.31	24.67
2006	20.74	4.54	0.91	0.39	0.92	0.16	0.29	0.46	28.41
2007	22.32	5.27	0.95	0.48	1.1	0.18	0.31	0.45	31.07
2008	22.64	5.53	0.96	0.49	1.19	0.19	0.32	0.54	31.85
2009	26.08	6.46	1.06	0.42	1.29	0.21	0.32	0.69	36.53
2010	25.47	7.24	0.93	0.73	1.38	0.2	0.13	0.78	36.86
2015	41.11	11.59	1.59	0.88	0.96	0.99	0.16	0.43	59.49
2016	45.22	12.75	1.75	0.97	1.05	1.09	0.17	0.48	65.44
CAGR	10.75 %	10.32 %	8.10%	8.33%	7.27%	14.06 %	5.10%	11.29%	10.51%

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tudied and referred.

Mid-Block volume traffic is forecasted based on Growth Rates in Table 4-6 above. Capacity augmentation is carried out based on the forecasted traffic at mid-block.

Projected Traffic – Singapura Road (from CH: 0 to CH: 655)

Mid-Block CVC has been considered for the purpose of projecting for next 10 years with growth factor of 10.51% for all the categories of vehicles in general. The present volume of traffic flow for both the direction is 38491 PCU as described in section 4.5 above. The projected traffic at the Mid-Block is 10456 as presented in Table 4-7Table 4-7 below.

Table 4-7 Projected Traffic Details at Renaissance wood apartment to Wimac Junction (Two way)

Peak Hour	YEARS										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Mid Block CVC in PCU	3849	4254	4701	5195	5741	6344	7011	7747	8562	9462	10456

Capacity Augmentation

Design Services volumes for different categories of urban roads are recommended in Table 4-8 below (as per IRC 106: 1990)

Table 4-8 Recommended Design Services volume (PCUs / Hour)

No. of traffic lanes	Divided / Undivided	Traffic flow	Total Design Service Volumes for Different Categories of Urban Roads		
			Arterial	Sub-Arterial	Collector
2-lane		One way	2400	1900	1400
Two way		Two way	1500	1200	900
3-lane		One way	3600	2900	2200
4-lane	Undivided	Two way	3000	2400	1800
	Divided	Two way	3600	2900	
6-lane	Undivided	Two way	4800	3800	

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lanes					
			Arterial	Sub-Arterial	Collector
	Divided	Two way	5400	4300	
8-lane	Divided	Two way	7200		

4.8 Capacity augmentation proposals (Lane requirement)

4.8.1 Improvement proposal for Singapura Road (from CH: 0+000 to CH:655)

The traffic from the Bangalore Metropolitan Area, the Region from outskirt of Bangalore to the work areas along this Access Street Road of Dasarahalli gets dispersed through the ring roads (BEL). This street road suffer from congestion because of their over utilization of their limited capacity within the limited carriageway width of 6m for two way traffic and roads is undulating due to frequent repairs of utility service laid within the area of road . In addition the limited carriageway, and their incapability to handle the present volume of traffic, further reduces the capacity of the road systems. Accordingly it has found necessary that this project road require improvement through widening 2 lane carriageways with additional space for footpath and utility ducts in order to cater to projected road traffic up to the year 2030 where the traffic demand of 10456 PCUs far exceeds the capacity and at grade expansion is required by widening the road on either side.

The Bangalore Development Authority in its revised Master Plan (RMP-2015), under Map widening from Dasarahalli Road for Singapura Road RMP map for project road is shown in Figure 4-5. According to the IRC, for present traffic flow capacity will be forced to expand to 2 lanes with footpaths and utility ducts. Currently the project road is 6 m to 10 m right of way and on either side is developed Residential/private land. Land is proposed for acquisition through TDR process.

It has been now proposed to widening of the existing carriageway to 12m wide from Abbigere main road junction to Shrinikethan BDA layout for a length of 655m in Singapura Garden road to increase the capacity of traffic to the extent possible which will reduces the delay in congestion and time.

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Figure 4-5 BDA RMP-2015 map showing the proposed road width of 12 meters for Singapura Garden Road

4.8.2 Improvement proposal Singapura Road (CH: 0 to CH:655)

This Acess street of Singapura road is nearby Jalahalli Airfoce road which as Sub arterial roads suffer from congestion because of their over utilization of their limited capacity. In addition the limited carriageway, and their incapability to handle the present volume of traffic, further reduces the capacity of the road systems. Accordingly it has found necessary that this project road require improvement through widening 2 lane carriageways with additional space for footpath and for utility ducts, in order to cater to projected road traffic up to the year 2030 where the traffic demand of 10456 PCUs far exceeds the capacity and at grade expansion is required.

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ding the capacity and need capacity augmentation.

ver it was decided in the regular review meetings with BBMP that widening sal will be made for the project road from Abbigere Main Road junction to ikethan BDA Layout in Singapura Road CH: 0 to CH:655 for 12m wide to develop rm cross sections and redesign of existing road for making the roads more efficient to le the projected traffic in feature.

Traffic Survey Photos

photos captured during traffic survey are shown in the Figure 4-6 below.

raffic survey at Ch 250

Figure 4-6 Photos Captured During Traffic Survey

5 Design Standards

5.1 General

Urban roads in India have a heterogeneous mix of traffic. These include the pedestrians, slow moving vehicles like bicycles, rickshaws both for passenger and freight movement and fast motorized vehicles like motorcycles, scooters, three wheelers, cars and public transport vehicles. The space occupied by each of these vehicles, accelerations and deceleration characteristics and possible maximum speeds by each user is variable. Therefore space allocation to different vehicles has to be carefully ensured to achieve a smooth and safe flow of traffic. The type and character of each urban road needs to be carefully detailed to respond to the functions it performs, i.e. providing mobility or access or both. Safety of road

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geometric design standards on ...

A design of the entire road cross-section holds considerable importance, as

- It governs the design speed of vehicles;
- Reflects prioritization in space allocation
- Introduces universal design and traffic calming concepts

5.2 Hierarchy of Urban Road

An efficient urban road network follows a hierarchy. The hierarchy is based on the function that the road is expected to perform, and the type of traffic and the road users present on the road. The design speeds, road widths and other geometric features are adapted to suit the road function. These guidelines are based on the classification of urban road: In India, IRC has revised the Engineers Pocketbook for Highway Construction to include classification and definition of urban roads. The classification of urban roads is given in following Table 5-1 below.

Table 5-1 Classification of urban roads

Road Typology	Right of way	Design Speed Km/h
Arterial Roads	50 to 80m	50
Sub-Arterial Roads	30 to 50m	50
Distributor/Collector Roads	12 to 30m	30
Access Streets	6 to 15m	15

5.3 Elements of Design

The alignment of any road comprises of various elements that together will create a safe and smooth facility for the intended function. Following factors listed below in Table 5-2 are considered for design:

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Cars and two wheelers	capacities	of abutting property	reaction distance
Ability to make decisions and reaction time	Design hour turning movements	Vertical and horizontal alignment at the intersection	Maneuver distance
Driver expectancy	Size and operating characteristics of vehicles.	Sight distance	Queue storage distance
Conformance to natural path of movement	Types of movement	Angle of intersection	
Pedestrian Behaviour	Vehicle Speeds	Conflict area	
Behaviour of cyclists	Transit involvement	Geometric features	
	Accident experience	Traffic control devices	
	Traffic mix, i.e. proportion of heavy and light vehicle and including pedestrians and NMV users.	Lighting equipment's	
		Environmental features(Trees, landscaping)	
		Presence of street vendors	

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distance for different speeds are shown in Table 5-4 below.

Table 5-3 Friction factor values

Speed, km/h	20 to 30	40	50	60	65	80	100
Longitudinal coefficient of friction, f	0.4	0.38	0.37	0.36	0.36	0.35	0.35

Table 5-4 stopping sight distance values for different speeds

Design speed(km/h)	lag distance (m)	Braking distance (m)	stopping sight distance	
			Calculated (m)	Design (m)
20	13.9	3.9	17.8	20
30	20.8	8.8	29.7	30
40	27.8	16.6	44.3	45
50	34.7	26.6	61.3	65
60	41.7	39.3	81	85

The sight distances on urban road are determined as:

$d=278\ V\ t + 0.039\ V^2 / a$
d = decision sight distances, m; V = design speed, km/h; a = deceleration rate, m/s2 ; t = pre-maneuver time, s (Stop on urban road—t = 9.1 s)

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1. Summit curves or crest curves with convexity upwards,
2. Valley or sag curves with concavity downwards

5.1 Summit curves:

ne problem in designing the summit curve is to provide adequate sight distances. The SSD ould be provided at all sections of the road system. Simple parabolic curve is used as th mmit curve due to the following reasons.

i. Parabola is very easy for arithmetical manipulations for computing ordinates
i. Use of simple parabola as summit curve is found to give good riding comfort

6 Design of Horizontal Alignment

orizontal alignment consists of circular portion flaked by spiral transitions at both ends arious design factors to be considered in the horizontal alignment are design speed, radiu circular curves, type and length of transition curve, super elevation, and coefficient o le friction and widening of pavement on curves

7 Design Speed

e design speed is the main factor governing the design of various design features. The sign speed depends on the following factors like sight distance, radius of horizonta rve, super elevation, extra widening of pavement, length of transition curve, length o mmit and valley curves. IRC: 86-1983 Design speed is shown in Table 5-5 and the ction factor for different design speeds is shown in Table 5-6.

Table 5-5 Recommended design speeds for different classes of urban roads

Road Typology	Design speed(km/hr)
Arterial Roads	50
Sub Arterial Roads	50
Distributory/Collector Roads	30
Access Streets	15

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5	0.4	0	0.4	4	5
0	0.35	0	0.35	9	10
0	0.25	0.02	0.27	26	30
0	0.23	0.04	0.27	47	50
0	0.19	0.06	0.25	79	80

Carriageway

This includes the number of lanes required for throughput of motorized traffic. Public transport vehicles also include LANE WIDTHS in motor vehicles The lane widths of a carriageway affect the safety and driving behavior of drivers. Wide lanes encourage higher speeds.

Horizontal clearance

For urban arterials, sub arterials, collectors, and local streets where curbs are utilized, space for clear zones is generally restricted. A minimum offset distance of 500 mm should be provided beyond the face of the curb, with wider offsets provided where practical. However, since most curbs do not have a significant capability to redirect vehicles, a minimum clear zone distance commensurate with prevailing traffic volumes and vehicle speeds should be provided where practical.

According to IRC: 86-1983 design speed and carriageway width recommended for different road categories are shown in Table 5-7 below

Table 5-7 Design speed and carriageway width recommended for different road categories

	Arterial Roads	**Sub Arterial Roads**	**Distributary Roads**	**Access Roads**
Carriageway				
Criteria	50 km/h	50 km/h	>30 km/h & < 50 km/h	>15 km/h & >30 km/h
ROW	50m – 80m	30m – 50m	12m – 30m	6m – 15m
Horizontal	30m or more	30m or more	10m or more	5m or more

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lanes	lanes divided (using a raised median)	Minimum 4 lanes divided (using a raised median);	Maximum 4 lanes of3.0m width each(excluding marking) or2 lanes of 3.0 to 3.3mwidth each (excluding with or without an interittent median)	
Minimum Width for car lane	3.0 to 3.5m width each	3.0 to 3.5m width each	2 lanes of 3.0 to 3.5m width each	2.75 to 3.0m widt each
Minimum Width for Bus lane	3.5m - (segregated)	3.5m -(segregated) or painted lane	Mixed traffic	

5.9 Pavement Design

Designs for new pavement and overlays shall be produced in accordance with IRC code Generally, the recommendation for rehabilitating the existing pavement depends upon th functional condition, structural condition of the pavement, Subgrade type, Subgrad strength and characteristics. Once the improvement proposals are finalized the pavemer composition shall be designed as per IRC: 37:2018 Overlay design as per IRC 81-1997.

5.10 Storm Water Drainage

Drainage should be addressed while design of cycle lanes and tracks to prevent ponding an erosions during rains. This would ensure safe usage of bicycle track. Improper design o gully gratings, water collection on the edge of bicycle lanes/tracks will hinder the comfor of riding and will prevent cyclists from its usage.

In arterial roads, by design there should be a segregated bicycling facility or a cycle track In such cases, there would be a strip/area segregating the carriageway and the bicycle track This area can be designed where the collection of water takes place i.e. a gully grating ca be located from where a pipe can be laid to the main storm drain.

The storm water drain can run under the footpath or any area other than below the cycle track because it will hamper the work/movement of cyclists. The water from th carriageway collects into the grating. Also the slope of the cycle track (2%) is towards thi area and seeps into the grating by surface drainage. When there is a swale or a green area

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in times of an open manhole or annual maintenance. The cache for the distributor and available for movement. This can be easily done by placing the cache for the distributor and access streets on the edge of the footpath

A bell mouth arrangement to collect water is not recommended. The grating should be flush with the floor of the carriageway and the cover should not hamper the movement of cyclists. The cover of the grating should be perpendicular to the direction of the travel of bicyclists so that the type does not get stuck and make the cyclist fall.

Storm water drain shall be designed based on the IRC –SP-42-2014 guidelines of road drainage.

5.11 Utilities

Road utilities are required to provide the necessary service to the roads and the neighboring areas. Although utilities generally have little effect on the geometric design of the highway or street, full consideration should be given to measures, reflecting sound engineering principles and economic factors needed to preserve and protect the integrity and visual quality of the highway or street, its maintenance efficiency, and the safety of traffic.

The some guiding principles which should be taken into account while designing the cross section of an urban road are:-

Utilities should be considered: Before working on the plan, Implication on cross-sectional design Implication on materials and design.

It is necessary to accommodate utility services along and across the roads. The laying design of utilities has to be done to ease maintenance and operations but keeping in mind that it will affect the traffic flow and conflict with other services to the minimum. Location should be taken up so that minor or no adjustments are required with road works taken up later. Some of the Utility service lines required to be laid down in the roads are listed in Table 5-8 below.

Table 5-8 List of Utility Service lines

Sl No	Type of Service lines
1	Sewer and drainage
2	Storm Water Drain
3	Water Supply lines
4	Electricity Cables
5	Telecommunication cables

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